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More Efficiency of Solar Energy System in Libya Using Artificial Intelligence (Fuzzy Logic Control)

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Recently, the entire world is facing the problem of energy. One method of harnessing incident solar radiation to generate power without releasing carbon dioxide (CO2) is solar photovoltaic (PV) energy. So, it's critical to give a broad summary of Libya's current energy production situation. The purpose of this paper was to shed light on the energy issues that the Libyan state is now dealing with, as well as the potential for diagnosing and outlining a plan for developing and locating solutions that make the most of solar radiation. The majority of the nation's energy consumption—roughly 36%—comes from residential building loads. This paper focus to how solar PV is currently being used in Libya and suggests using artificial intelligence as a controller to boost the effectiveness of the solar energy system. Using Fuzzy Logic controller (FLC) to collect the largest amount of energy which can reach 95% or more, by control tracking the radiation of the solar, cleaning and control on the temperature solar board.

Keywords: Solar PV applications, Renewable energy in Libya, Fuzzy Logic control (FLC), Sun tracker, Solar panels Cleaning System, Temperature.

1. Introduction

Solar energy is the focus of the source of energy in the modern world and efforts to achieve maximum efficiency by using photovoltaic cells by artificial intelligence. The main factors that affect the efficiency of solar panels are solar radiation, high temperature, and dust. The most brilliant light caught by the sunlight-based charger is addressed as the light force. The result of the sun-powered global positioning framework is gotten by tracking down the best worth of light force between LDRs. Energy from sun is vast amount and if by using modern techniques we flip this energy into electricity it may help to fulfil needs of power where there is shortage, and it has a benefit of being inexhaustible and ecofriendly. Also due to extreme weather conditions in targeted area automated cleaning is focus for solar plates to increase the efficiency of solar energy received [1]. If we see today the world without Electric power, it would be a devastating picture. Sunlight is converted into electricity using solar cells made of silicon. In total, Libya is home to daily average solar radiation of 7.1 kWh per m2 in its coastal region and 8.1 kWh per m2 in its southern region, along with more than 3,500 hours of average annual sun duration and 140,000 TWh per year of concentrated solar potential [2]. The rate of conversion depends on the amount of sunlight hitting the cells which refers to the angle of the panels whether they are fixed or moving. Basically, there are two types of panels, Fixed and solar tracking panels. Furthermore, tracking panels are divided into single axis rotation or dual axis rotation. In tracking panels system, the panels rotate around with the reference of the sun to form maximum solar energy. The data shows the comparison between fixed and tracking solar panels efficiency [2]. With all this huge amount of solar energy, the climate in Libya limits the optimal use of energy, where high temperature and the amount of dust play a negative role. Hence, it was necessary to take advantage of artificial intelligence, including fuzzy logic techniques to increase the efficiency of solar panels by reducing the effect of these factors.

2. Libya's Current Electrical Energy Condition and Related Difficulties

A. Climate in Libya

Libya's climate is influenced by the Sahara Desert to the south and the Mediterranean Sea to the north, which causes rapid changes in weather across the entire nation. Winters are comparatively damp and summers are dry along the Mediterranean coast. The plateau climate of the Jabal Nafusah and Jabal Akhdar highlands is characterized by increased rainfall, greater humidity, and colder winter temperatures. The highest average annual rainfall, above the minimum value of 250–300 mm, is experienced in the northern Tripoli regions of Jabal Nafusah and Jifarah Plain and the northern Benghazi region of Jabal al Akhdar. In the southern portion of the interior, where rain is infrequent and erratic, pre-desert and desert conditions with sweltering temperatures with daily thermal changes are present. Winter months in Libya are rainy, with an average yearly rainfall of 26 mm and wide variances from location to location and year to year. Less than 100 mm of rain fall on about 93 percent of the area each year [3]. Figures 1, 2 show the average monthly solar radiation and average monthly temperature, respectively, in Libya in 2019. According to data from the US Department of Energy National Laboratory [4].

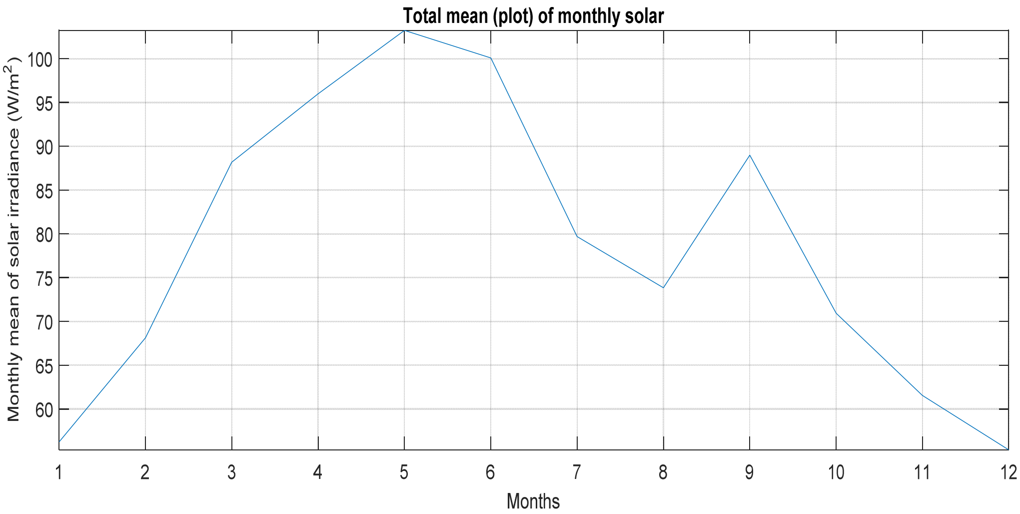

Figure 1. Monthly mean of solar irradiance in year 2019

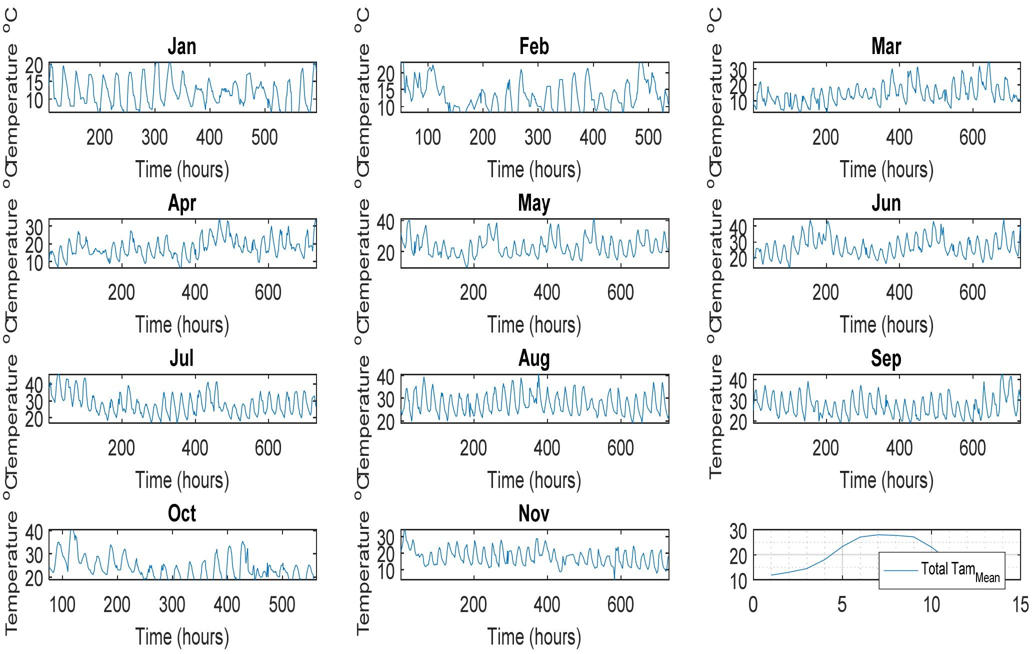

***Figure 2**. Monthly mean of temperature in year 2019*

B. The electrical energy situation in Libya

The General Electricity Company of Libya oversees the country's electrical grid (GECOL). The state-owned firm oversees and operates the network, generation, transmission, and distribution systems [5]. As a result, the position poses a lot of difficulties for GECOL. Most crucially, it has trouble giving its clients the quantity and caliber of electricity they want [6]. Due to Libya's total reliance on fossil fuels to produce electricity, natural gas and oil are the country's principal energy sources. Libyan power plants rely on light and heavy oil, with a growing reliance on natural gas. Libya's demand for energy has risen quickly as a result of population growth and the emergence of construction projects. In addition, Libya often consumes a lot of electricity because it is one of the biggest energy consumers in Africa [7]. This is caused by a number of things, including social customs and cultural conventions, but the primary cause is the electricity subsidy rate [8]. As a result, the difference between the generation price and the tariff cost charged to the client is indeed substantial. But on the other side, this hybrid renewable energy system's deployment attempts to lower the cost of production [9].

Pregnancy had been steadily increasing for over a decade before 2011, but after that time in 2013, the pattern changed too rapidly rising pregnancy needs (Mohammed et al., 2013). Consumption was estimated to be 5.5 GW in 2011 and was projected to increase exponentially to 9 GW in "2020" [6]. Figure 3 depicts the development of electrical calculation in the Libyan network. The need for loads increased as a result of the significant growth in construction. On the other hand, the network has not developed to match this demand. Additionally, the current power plant units require significant maintenance on a regular basis after specific working hours. The Libyan General Electricity Company (GECOL) has also engaged with manufacturers to provide thorough repair work for power plants due to the war and the vulnerable security environment. Therefore, sadly, no enterprise is ready to dispatch its experts or engineers to the state to do extensive maintenance on power producing units. . According to historical load profile data in Libya, the residential sector accounts for the majority of the demand for electric power, which is 36 percent, and that greatest power occurs during the summer months. It is successively followed by 23% of the others, with 14% representing the commercial/industrial sector [7]. In Libya, population expansion is significantly raising the demand for electricity, creating a huge need for new infrastructure construction, including power lines and expanding power plants. Additionally, continuous power plant operation and higher fuel consumption are required for industrial development. This resolution asks the Libyan government to investigate, utilize, and assess the viability of renewable energy technology [10].

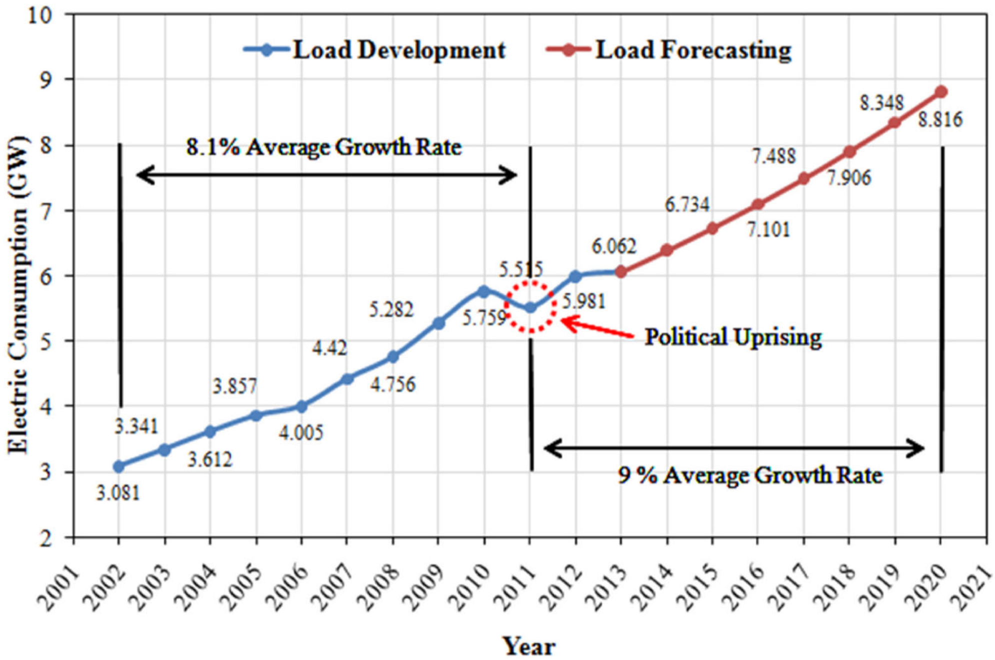

Figure 3. Development of electrical computation in Libyan grid from 2001 to 2020 [7].

3. Artificial Intelligence (AI)

Artificial intelligence is the simulation of human intelligence processes by machines, especially computer systems. Specific applications of AI include expert systems, natural language processing, speech recognition and machine vision. Artificial intelligence is frequently employed in computer systems that have the right hardware and software. Machine intelligence is another name for artificial intelligence. Particle swarm optimization, evolutionary intelligence algorithms, fuzzy logic, and artificial neural networks are the four basic categories used to classify artificial intelligence techniques [11].

A. Fuzzy logic (FL)

Fuzzy Logic is a form of multi-valued logic derived from fuzzy set theory to deal with reasoning that is approximate rather than precise. Fuzzy logic is not a vague logic system, but a system of logic for dealing with vague concepts. Instead of dealing with data points, FL deals with the ranges of the various parameters. Consequently, FL could accurately forecast outcomes for all data points within the ranges of different parameters. The Mamdani and Sugeno modules are the only two available. Unlike the Sugeno module, where input parameters have different ranges and output parameters contain data points, the Mamdani module of FL divides both input and output parameters into ranges. Rules are defined in the fuzzy modular's rule editor depending on the values of the input-output parameters after membership functions have been chosen Figure 4 shows the general diagram of fuzzy model [12,13].

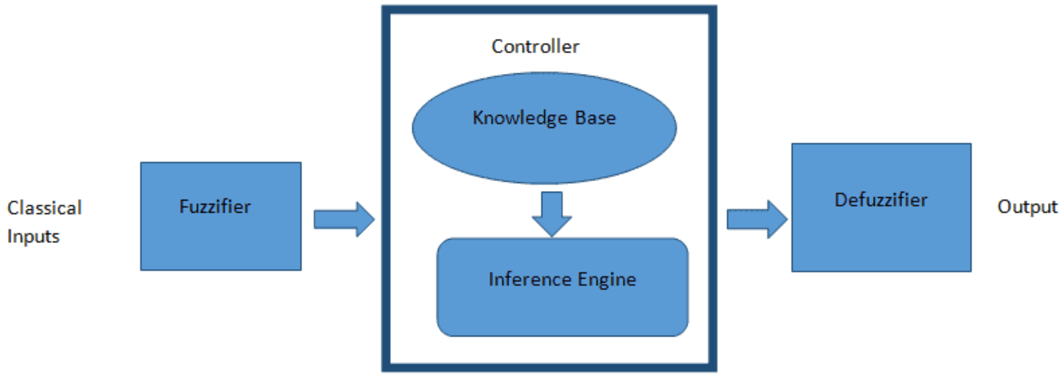

Figure 4. General diagram of fuzzy model

1. Fuzzifier: It accepts the measured variables as input and converts the numerical values to linguistic variables. It transforms the physical values as well as the error signals to a normalized fuzzy subset which consists of an interval for the input values range and membership functions that describe the probability of state of the input variables.

2. Controller: It consists of the knowledge base as well as the inference engine. The knowledge Base stores the membership functions and the fuzzy rules, obtained by knowledge of system operation per the environment. The inference engine performs processing of the obtained membership functions and fuzzy rules. In other words, the inference engine assigns outputs based on linguistic information

3. Defuzzifier: It performs the reverse process of the Fuzzifier. In other words, it converts the fuzzy values to the normal numerical or physical signals and sends them to the physical system to control the system operation.

B. Mamdani module

Ebhasim Mamdani created the Mamdani Fuzzy Inference Theory, which is a fuzzy logic theory. It was initially developed utilizing a set of linguistic control rules to run a steam engine and boiler combination [13].

4. Practical Part

In this experiment, fuzzy logic was used to increase the efficiency of the solar panel, where the inputs (light level, dust level, and temperature. were used as shown in the table1, where Fuzzy Logic Designer (Mamdani module) was used.

Table 1. *light level, dust level, temperature, and efficiency rate*

Level	Light 0-100%	Dust 0-100%	Temperature 0-45	Efficiency0-100%
Very low	0-15	0-5	0-5	0-15
Low	15-40	5-15	5-10	15-40
Medium	40-70	15-30	10-25	40-70
High	70-90	30-60	25-35	70-90
Very high	90-100	60-100	35-45	90-100

5. The Rule Structure:

The rule structure is composed of IF X AND Y THEN Z rules as follows:

IF (light is very high) AND (temperature is very low) THEN (efficiency is very high)

IF (light is high) AND (temperature is low) THEN (efficiency is high)

IF (light is high) AND (temperature is medium) THEN (efficiency is medium)

IF (light is medium) AND (temperature is high) THEN (efficiency is medium)

IF (light is high) AND (temperature is very high) THEN (efficiency is low)

IF (light is very low) AND (temperature is very high) THEN (efficiency is very low)

IF (light is low) AND (temperature is high) THEN (efficiency is very low)

IF (light is very low) AND (temperature is very low) THEN (efficiency is very low)

IF (light is low) AND (dust is very high) THEN (efficiency is very low)

IF (light is medium) AND (dust is very high) THEN (efficiency is very low)

IF (light is medium) AND (dust is high) THEN (efficiency is very low)

IF (light is low) AND (dust is high) THEN (efficiency is low)

IF (light is medium) AND (dust is low) THEN (efficiency is medium)

IF (light is medium) AND (dust is very low) THEN (efficiency is medium)

IF (light is high) AND (dust is low) THEN (efficiency is high)

IF (light is very high) AND (dust is very low) THEN (efficiency is very high)

IF (light is high) AND (dust is very low) THEN (efficiency is very high)

IF (light is very high) AND (temperature is very high) AND (dust is very high) THEN (efficiency is very low)

IF (light is very low) AND (temperature is medium) AND (dust is very low) THEN (efficiency is very low)

IF (light is very high) AND (temperature is medium) AND (dust is very high) THEN (efficiency is very low)

IF (light is very high) AND (temperature is very high) AND (dust is very low) THEN (efficiency is very medium)

6. Results and Discussion

The data was collected using MATLAB to simulate the factors affecting solar energy efficiency in the climate of Libya, and the results are shown in Table 2 and Figure 5.

***Table 2**. light level, dust level, and temperature, VS efficiency rate*

Light %	Dust %	Temperature C°	Efficiency %
50	50	22.5	12.5
100	97.3	22.5	13.2
94	7	42	57.1
10	10	5	13.2
98	5	33	96.8

***Figure 5.** The best efficiency rate is obtained by using the fuzzy logic designer for the parameters (light, temperature and dust).*

From the previous results, we can conclude that the highest efficiency rate of the solar panel can be obtained as follows:

- Track the highest rate of sun radiation.
- Keeping the solar panel clean from dust.

 Maintaining a moderate temperature of the solar panel.

Since the temperature cannot be completely controlled, as is the case in both the amount of dust and the intensity of lighting, we must focus on both, taking into account the attempt to find a solution to the temperature factor affecting the efficiency of the solar panel.

6. Conclusion:

The use of artificial intelligence has become common in many systems that need very high accuracy. Through this study and the results obtained using the Matlab program, it is possible to obtain greater efficiency by using artificial intelligence (fuzzy logic technology) to control which will increase the efficiency of the output of solar panels, which can reach 96.8%, where the fuzzy logic can be used, And that is by controlling the sun's radiation tracking, cleaning and controlling the temperature of the solar panel.

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